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| 09/941,963 | 08/28/2001 | Sunfei Fang | 01P14755 US | 7736 |
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| SLATER & MATSIL, L.L.P. 17950 PRESTON RD, SUITE 1000 DALLAS, TX 75252-5793 | | | EXAMINER LEE, HSIEN MING | |
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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application N .

09/941,963

Applicant(s)

FANG, SUNFEI

Examiner

Hsien-Ming Lee

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 13 February 2004.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-4,6-13,15-19 and 21-27 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-4,6-13,15-19 and 21-27 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date _____.
- 4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date _____.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other: _____.

DETAILED ACTION

1. Claims 24-27 are newly added. Thus, claims 1-4, 6-13, 15-19 and 21-27 are pending in the application.

Claim Objections

2. Claims 6-8 and 24 are objected to because of the following informalities: in-consistent terms, i.e. “anisotropic, ion enhanced etch” (claim 24, line 9) versus “the etch” (claim 7, line 1) and “the organic etch” (claim 8, line 2).

In addition, the term “of the organic material” (claim 6 and 7) lacks antecedent basis since the term does not appear in the base claim 24 (see line 9). Appropriate correction is required.

In re claim 24, at line 7, “clean of the hold” should be – clean of the hole --.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

4. Claims 1-4, 6-13, 15-19, 21 and 23-27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dixit et al (US 5,849,367) in view of Li et al. (US 2003/0024902) and Blickensderfer et al. (US 4,098,956).

In re claims 1, 3, 6, 10-12, 16-17, 19, 21 and 24-26, Dixit et al. teach a method of cleaning a previously etched hole 28 formed in an organic inter-level dielectric 26 (col. 6, lines 18-20 and col. 8, lines 4-6), the hole 28 having a sidewall surface 42 defined by said organic ILD and a

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bottom comprising a layer of surface oxide (i.e. Ti_yO_x or Al_2O_3 , col. 5, lines 47-49) formed during the etching of said hole 28, the organic ILD disposed on a semiconductor substrate 22/24, the method comprising:

- forming a plasma over an interconnect structure, the plasma comprising a mixed gas of argon and nitrogen (col. 6, lines);
- directing the plasma toward the interconnect structure, i.e. towards to a hole 28 comprising the interconnect layer 24 at a bottom of the hole 28;
- displacing organic ILD particles 40 from said sidewall surface 42, wherein the organic ILD particles 40 arise from the etching process that is used to form the hole 28 (col. 5, lines 39-40), and depositing said displaced organic ILD particles at said bottom of said hole 28 while performing a plasma sputter clean of the hole 28 to remove said surface oxide (i.e. Ti_yO_x or Al_2O_3 , col. 5, lines 47-49), using argon which acts as physical etch (col. 5, lines 43-45), at the bottom of said hole 28;
- removing organic particles displaced from the sidewalls 42 and deposited at the bottom of the hole 28 during the sputter clean by performing an anisotropic ion enhanced etch of the hole 28, using nitrogen (col. 6, lines 30-31), during at least a portion of the sputter clean; and
- forming a plug 50 in the hole 28 (Fig.4).

In re claims 1 and 24, Dixit et al do not expressly teach that the plasma sputter is a radio frequency (RF) sputter.

However, Li et al, in an analogous art, teach utilizing RF sputter (paragraph [0026]) for the purpose of cleaning organic residue resided within the hole (paragraph [0030]) that formed in the

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organic ILD dielectric (such as layers 34 and 38, see Fig.2D), wherein the mixed gas used in the RF sputter comprises argon or helium and nitrogen (paragraphs [0031]~[0032], [0041]).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to use RF sputter, as taught by Li et al., as the sputter of Dixit et al, since by this manner it would be beneficial to the anisotropic etching (paragraph [0034], Li et al.).

In re claim 9, Dixit et al. also teach that the hole 28 is a part of an interconnect structure, wherein a conductive layer 24 is disposed at a bottom of the hole 28, and the sputter clean removes a surface of oxide (i.e. Ti_yO_x or Al_2O_3 , col. 5, lines 47-49) formed on the conductive layer 24.

In re claim 23, Dixit et al. also teach forming a liner 42/47 in the hole 28 before the forming of the plug 50 (Fig.4).

In re claims 2, 10-11 and 25, in addition to the aforementioned limitations, Dixit et al. also teach that argon in the mixed gas acts as physical etch (col. 5, lines 43-45) but do not expressly suggest that nitrogen acts as ion enhanced chemical etch.

However, nitrogen in the sputtering has been known as a chemically reactive gas, as evidenced by Blickensderfer et al. (col. 3, lines 50-53).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time the invention was made, to comprehend that nitrogen in Dixit et al. would act as ion enhanced chemical etch, in light of Blickensderfer et al, since nitrogen has been converted into ions by the plasma and these ions are chemically reactive capable of performing etching function.

In re independent claim 26, Dixit et al. in view of Li et al teach the claimed limitation, as stated above, except forming an upper conductive layer on the organic ILD 26 and the plug 50.

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However, the teachings of Dixit et al. in view of Li et al are illustrative rather than restrictive (paragraph [0049], Li et al.). One of the ordinary skill in the art, at the time of the invention was made, would have been motivated to modify the method without departing the scope and the spirit of the method by forming additional conductive layer on the organic ILD and the plug, since by this manner it would form a multi-level interconnect structure.

In re claims 4, 13 and 18, Li et al also remedy the deficiency in Dixit et al. that the sputter comprises an helium plasma. In particular, Li et al. teach helium is an art-recognized equivalent inert gas with respect to argon in sputter cleaning process (paragraph [0032]).

In re claims 7 and 15, Li et al also remedy the deficiency in Dixit et al. that the RF bias in the sputter is of between about 1 watts and about 500 watts. In particular, Li et al. teach that the RF bias in the sputter of between about 50 watts and about 1,000 watts. (paragraph [0034]).

In re claim 8, Dixit et al. in view of Li et al. also teach that the RF sputter clean and the organic etch are performed over about the same time interval because Dixit et al. teach using a mixed gas comprising argon and nitrogen in the sputter processing, wherein argon (i.e. a physical bombardment) is for the sputter clean, whereas nitrogen (i.e. a chemical bombardment) is for organic etch.

In re claim 27, Dixit et al. also teach that the hole 28 is a part of an interconnect structure, wherein a conductive layer 24 (i.e. a metal) is disposed at a bottom of the hole 28.

5. Claim 22 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dixit et al. et al. in view of Li et al. and Blickensderfer et al. as applied to claims 16 above, and further in view of Chooi et al. (US 6,284,657).

Dixit et al. et al. in view of Li et al. substantially teach the claimed invention except forming a lower cap layer on the lower conductive layer before the forming of the organic ILD layer and forming an upper cap layer on the organic ILD layer, wherein the etching of the hole further comprises etching through the upper cap layer and lower cap layer.

However, Chooi et al. teach forming a lower cap layer 12 on the lower conductive layer 10 before the forming of the organic ILD layer 14 and 18 (Fig.1), and forming an upper cap layer 20 on the organic ILD layer 18 (Fig. 10), wherein the etching of the hole 22/24 further comprises etching through the upper cap layer 20 and the lower cap layer 12 (Fig.11).

Therefore, it would have been obvious to one of the ordinary skill in the art, at the time of the invention was made, to integrate the teachings of Dixit et al. in view of Li et al. with the teachings of Chooi et al. in a such manner that an additional lower cap layer is formed on the lower conductive layer 24 in Dixit and another additional upper cap layer is formed on top of the organic ILD layer 26 in Dixit, prior to the plasma etching, since by this manner it would prevent underlying layers from undesirable etching damage.

Response to Arguments

6. Applicant's arguments with respect to claims 1-4, 6-13, 15-19 and 21-27 have been considered but are moot in view of the new ground(s) of rejection.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Hsien-Ming Lee whose telephone number is 571-272-1863. The examiner can normally be reached on M-F (9:00 ~ 5:00).

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 571-272-1855. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Hsien-Ming Lee
Examiner
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April 30, 2004